# APPENDIX B. ECOLOGICAL RISK ASSESSMENT

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# B.1 ECOLOGICAL RISK ASSESSMENT APPROACH[1]

Ecological receptors on and near Par Pond, L-Lake, Lower Three Runs, and Steel Creek might be at risk from contaminants present in their surface water, sediment, and biota as a result of the Proposed Action. Increased concentrations of tritium in other onsite streams also pose a potential ecological risk. Accordingly, an ecological risk assessment (ERA) that focused on the Proposed Action was performed to characterize the potential risks from site-related contaminants to ecological receptors that inhabit the waterbody areas. This section provides an outline of the general approach that was taken to assess the impacts of site contamination on ecological receptors and the habitats that support these organisms. This assessment generally followed a two-step process, as follows:

**Step 1: Preliminary Problem Formulation and Ecological Effects Characterization (Section B.1.1)**

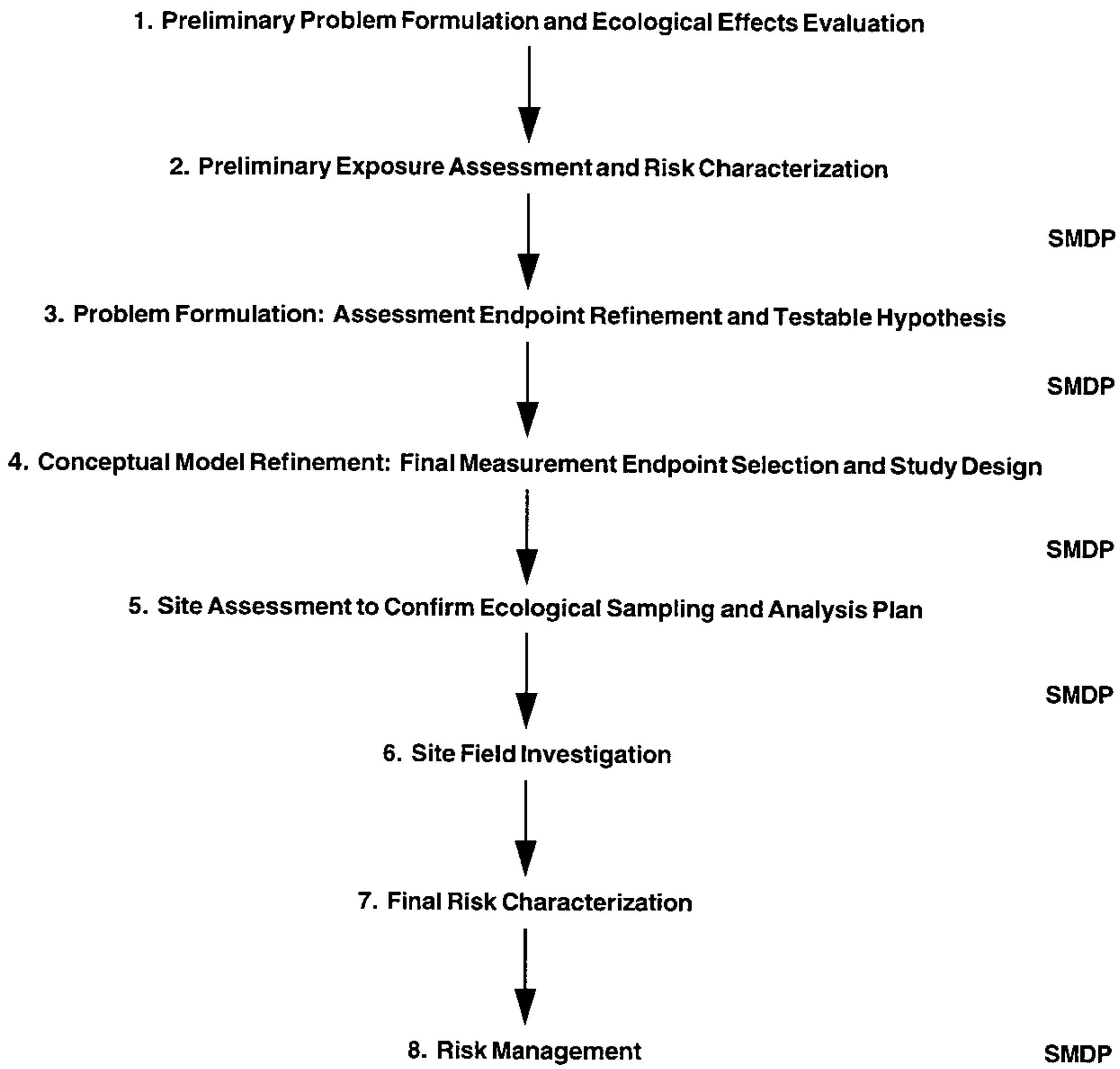
- Preliminary Problem Formulation - This is the first phase of an ERA, which discusses the goals, breadth, and focus of the assessment. It includes general descriptions of the waterbodies to be investigated with emphasis on the habitats and ecological receptors present. This phase also involves characterization of contaminant sources and migration pathways, evaluation of routes of contaminant exposure, and selection of ecological contaminants of potential concern (COPCs). Assessment and measurement endpoints that will be evaluated are also selected in this phase. Finally, a conceptual model is developed that describes how contaminants associated with the waterbodies may come into contact with ecological receptors.
- Ecological Effects Characterization - In this phase, medium-specific ecological screening values for each COPC (i.e., concentrations of each contaminant above which adverse effects to ecological receptors may occur) are identified. Receptor-specific toxicity reference values (TRVs) are also derived during this step. This step is undertaken concurrently with the exposure assessment described below.

**Step 2: Preliminary Exposure Assessment and Risk Characterization (Section B.1.2)**

- Preliminary Exposure Assessment - This portion of the ERA includes the identification of the data used to represent concentrations of contaminants to which ecological receptors may be exposed in various media and the actual selection of exposure point contaminant concentrations from those data. Calculation of receptor-specific contaminant doses is also performed.
- Risk Characterization - In this step, exposure point concentrations are compared to screening values in order to characterize potential risk to ecological receptors of concern from contaminant exposure. TRVs are also compared to contaminant doses. COPCs found to pose potential risk after these comparisons are placed on a list of ecological contaminants of concern (COCs).

When these two steps are completed, the results can be interpreted and the uncertainties associated with the ERA can be addressed. The above process, described in further detail below, represents the general ERA approach recommended in U.S. Environmental Protection Agency (EPA) guidance for Superfund (EPA 1996a), and is a summation of EPA Region 4 recommended ERA guidelines (EPA 1995a), which served as the basis for the ERA methodology (Figure B.1). Furthermore, the ERA was conducted in accordance with other available ERA guidance documents (EPA 1996b; Wentsel et al. 1996), and recent publications (Suter 1993; Calabres : and Baldwin 1993).

1 Appendix B was substantially expanded in response to a comment in the letter from EPA (L10-02); no change bars appear.




Source: Adapted from EPA (1996a).
SMDP: Scientific/Management Decision Points.

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**Figure B-1.** Steps in the Ecological Risk Assessment process.

Due to the potential complexity of ERAs, they are often conducted using a tiered approach and punctuated with Scientific/Management Decision Points (SMDPs; Figure B-1), which are meetings involving the risk assessors, risk managers, and clients to control costs, prevent unnecessary analyses, and ensure that the ERA is proceeding in an efficient, timely manner. Information analyzed in one tier is evaluated to determine whether the objectives of the study have been met and then may be used to identify the data required for the next tier, if necessary. This Tier 1 ERA can be considered a "screening-level" assessment, or "preliminary risk evaluation" (EPA 1995a), since it is based on only a conservative initial screening of contaminant concentrations against contaminant-specific screening values (EPA 1995a).

Tier 2 and Tier 3 assessments, referred to as "semi-quantitative" and "quantitative" assessments, respectively, are more focused studies that incorporate the initial screening but also encompass detailed laboratory and field studies or extensive modeling (EPA 1996a). This ERA, designed to focus mainly on the potential risks to ecological receptors from contaminant exposure that could result from the Proposed Action, may be useful for Tier 2 or Tier 3 assessments that may be conducted as part of the remedial investigation/feasibility study process. The same process summarized above was used to assess potential ecological risks at each waterbody investigated in this ERA.

## B.1.1 Preliminary Problem Formulation and Ecological Effects Characterization

Section B.1.1.1 discusses the components of preliminary problem formulation and Section B.1.1.2 discusses the components of ecological effects characterization.

### B.1.1.1 PRELIMINARY PROBLEM FORMULATION

Site Backgrounds and Ecological Settings

The preliminary problem formulation of an ERA contains a description of the background of each study site as well as a description of the ecological setting. However, as detailed descriptions of these items have been presented elsewhere in this EIS, they will not be presented here.

**Habitat Types and Ecological Receptors**

The preliminary problem formulation of an ERA also contains a description of the specific habitat types and ecological receptors that are found on each study area. However, detailed descriptions of these items are presented elsewhere in this EIS.

**Major Contaminant Sources, Migration Pathways, and Exposure Routes**

The major contaminant sources for all waterbodies are sediments. As such, contaminants are largely bound to sediments and are not expected to significantly migrate to other areas or other media. It is likely that receding or fluctuating water levels would lead to the exposure of sediments to the elements, creating new surface soils. This would also preclude significant contaminant migration via surface water as water levels decrease. However, a potential migration pathway is resuspension of contaminants into surface water via fluctuating water levels. Constituents in the exposed sediments (soils) may also volatilize from surficial material or become airborne via resuspension. Contaminated fugitive dust may also be generated during ground-disturbing activities, such as recontouring of the L-Lake basin that may be necessary. Yet, volatilization and fugitive dust generally represent a negligible release pathway and exposure route for wildlife except in certain situations, such as following a large spill of a volatile compound. Since the water bodies of concern in this assessment were already considered to be contaminated and do not potentially receive groundwater contaminated with non-radiological contaminants, the groundwater-to-surface water pathway was not applicable.

Aquatic and semi-aquatic organisms inhabiting the waterbodies of interest in this ERA may be exposed to contaminants via direct contact with surface water, submerged sediments, and exposed sediments, via incidental ingestion of surface water, submerged sediments, and exposed sediments, and via consumption of contaminated food items. Again, since water levels are assumed to recede in the reservoirs, exposure to contaminants in surface water was considered only in certain instances in this assessment, such as at Par Pond, where water levels will be maintained and will fluctuate.

**Selection of Ecological Contaminants of Potential Concern**

COPCs were all contaminants, both radiological and non-radiological, detected in the studies that are discussed in detail in Section B.1.2.1. However, for the non-radiological contaminants, calcium, iron, magnesium, potassium, and sodium were excluded as COPCs since they are essential nutrients that are toxic only in extremely high concentrations. For radiological contaminants, potassium-40 was excluded since it is a naturally occurring radionuclide. Also, radiological and non-radiological contaminants that were detected in 5 percent or less of the samples collected in any medium for any study at each area were initially excluded as COPCs.

**Assessment and Measurement Endpoints**

As discussed in EPA (1995a) and Wentsel et al. (1996), one of the major tasks in problem formulation is the selection of assessment and measurement endpoints. An assessment endpoint is defined as "an explicit expression of actual environmental values that are to be protected" (EPA 1996b). Measurement endpoints are "measurable ecological characteristics that are related to the valued characteristic chosen as the assessment endpoint" (EPA 1996b). For this ERA, the most appropriate assessment endpoint was the maintenance of aquatic and terrestrial receptor populations. Note that the maintenance of receptor populations applies only to exposure to contaminants. That is, it is not intended to relate to declines in certain receptor populations from physical changes as a result of the Proposed Action. Therefore, the specific objectives of this assessment were to determine if exposure to contaminants in the surface water, sediments, and exposed sediments (surface soils) on and near Par Pond, L-Lake, Lower Three Runs, and Steel Creek are likely to result in declines in ecological receptor populations, primarily as a result of the Proposed Action. Declines in populations as a result of contaminant exposure could result in a shift in community structure and possible elimination of resident species from aquatic environments.

It should be noted that for this screening-level ERA, broad assessment endpoints were conservatively selected to apply to all possible species. More focused assessment endpoints will be selected if additional, more focused ecological investigations are warranted. These more focused endpoints would likely be contaminant-specific or applicable to only species that are shown to potentially be at risk in the screening-level ERA.

As indicated above, measurement endpoints are related to assessment endpoints, but these endpoints are more easily quantified or observed. In essence, measurement endpoints serve as surrogates for assessment endpoints. While declines in populations and shifts in community structure can be quantified, studies of this nature are generally time-consuming and difficult to interpret. However, measurement endpoints indicative of observed adverse effects on individuals are relatively easy to measure in toxicity studies and can be related to the assessment endpoint. For example, contaminant concentrations that lead to decreased reproductive success or increased mortality of individuals in toxicity tests could, if found in the environment, result in shifts in population structure, potentially altering the community composition of the waterbodies investigated in this ERA.

For surface water, the measurement endpoints were contaminant concentrations in surface water associated with adverse effects on growth, survival, and reproduction of aquatic organisms (surface water screening levels). Again, exposure to contaminated surface water was considered only in certain situations since surface water levels are generally assumed to fluctuate or recede, such as at L-Lake. For sediments, the measurement endpoints were contaminant concentrations in sediment associated with adverse effects on growth, survival, and reproduction of benthic organisms (sediment screening levels). For surface soils (exposed sediments), the measurement endpoints were contaminant concentrations in surface soil associated with adverse effects on growth, survival, and reproduction of terrestrial invertebrates (surface soil screening levels). For terrestrial plants, the measurement endpoints were contaminant concentrations in surface soil associated with adverse effects on growth, survival, and reproduction of vegetation (terrestrial plant screening levels). For terrestrial wildlife, the measurement endpoints were doses of contaminants associated with adverse effects on growth, survival, and reproduction (TRVs).

**Conceptual Site Model**

The conceptual model is designed as a diagram to identify potentially exposed receptor populations and applicable exposure routes, based on the physical nature of the site and the potential contaminant source areas. Actual or potential exposures of ecological receptors associated with the waterbodies assessed in this ERA were determined by identifying the most likely pathways of contaminant release and transport. A complete exposure pathway has three components: a source of contaminants that can be released to the environment; a route of contaminant transport through an environmental medium; and an exposure or contact point for an ecological receptor. A comprehensive conceptual model for this ERA is presented in Figure B.2.

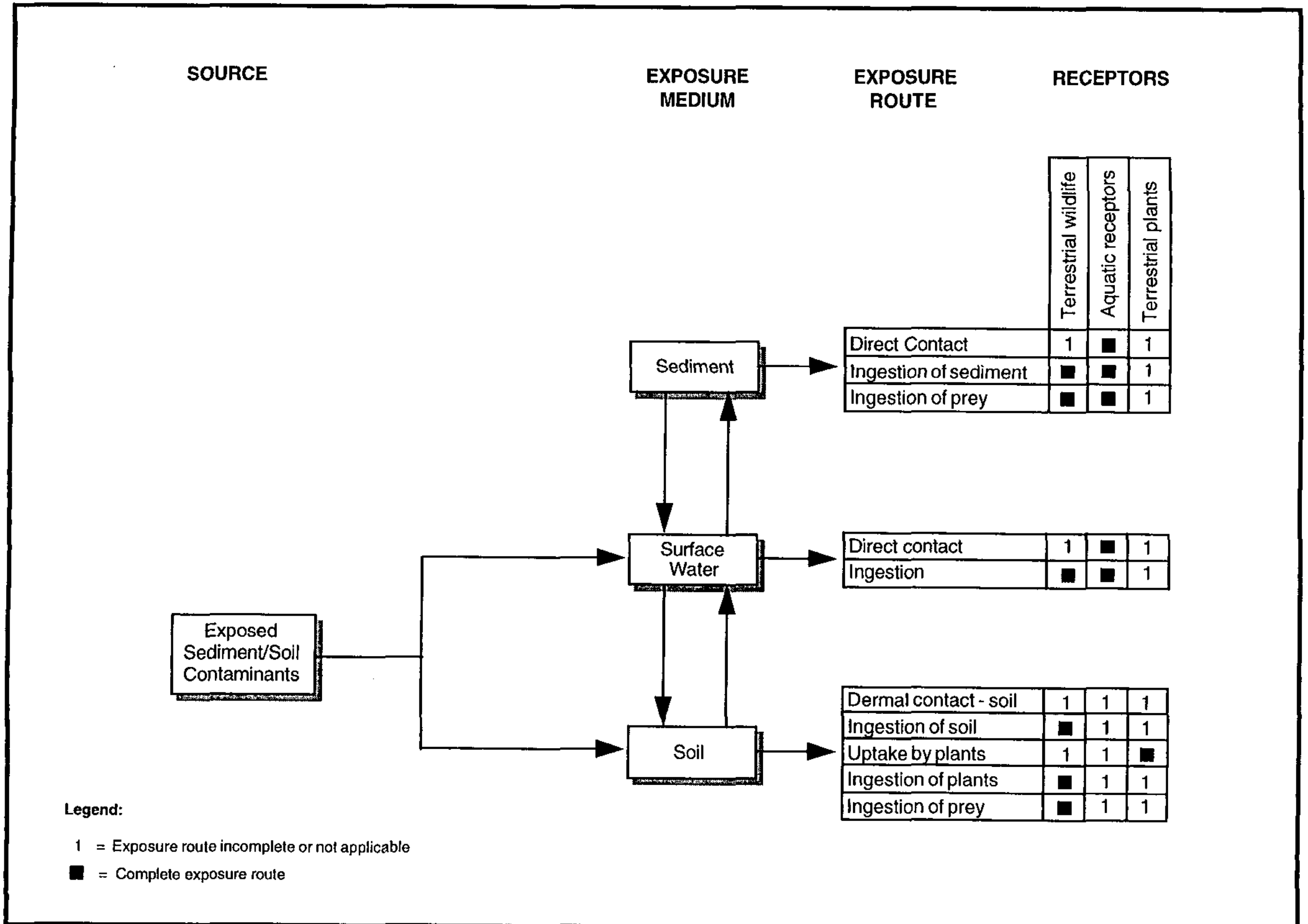
## B.1.1.2 ECOLOGICAL EFFECTS ASSESSMENT

### B.1.1.2.1 Non-radiological

For this ERA, ecologically-based screening values, concentrations of contaminants in various media protective of ecological receptors, were selected to screen exposure point concentrations of COPCs in surface water, sediment, and surface soil (exposed sediments) to determine if they should be retained as COCs. The focus of this assessment is primarily potential risks from submerged and exposed sediments, and therefore, surface water screening levels were obtained only for Par Pond. It is assumed that at L-Lake the water level will eventually recede to a small stream, rendering current assessment of potential risks from surface water contaminants irrelevant. Methods used for the selection of media-specific screening levels used in this ERA are provided below.

**Selection of Surface Water Screening Levels**

Surface water screening levels used for this ERA were primarily EPA Region 4 ecological screening levels for freshwater systems (EPA 1995a). When these values were not available for certain contaminants, suitable screening levels were obtained from EPA (1996c). Surface water screening levels used in this assessment are presented in Table B-1.




| Exposure medium | Exposure route | Terrestrial wildlife | Aquatic receptors | Terrestrial plants |
|---|---|---|---|---|
| Sediment | Direct Contact | 1 | ■ | 1 |
| Sediment | Ingestion of sediment | ■ | ■ | 1 |
| Sediment | Ingestion of prey | ■ | ■ | 1 |
| Surface Water | Direct contact | 1 | ■ | 1 |
| Surface Water | Ingestion | ■ | ■ | 1 |
| Soil | Dermal contact - soil | 1 | 1 | 1 |
| Soil | Ingestion of soil | ■ | 1 | 1 |
| Soil | Uptake by plants | 1 | 1 | ■ |
| Soil | Ingestion of plants | ■ | 1 | 1 |
| Soil | Ingestion of prey | ■ | 1 | 1 |

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**Figure B-2.** Conceptual site model for Par Pond, L-Lake, Lower Three Runs, and Steel Creek.

**Table B-1.** Ecological screening levels for Par Pond surface water.

| Contaminant of Potential Concern | Ecological Screening Level (µg/L) | Source |
|---|---|---|
| Aluminum | 87 | EPA Region 4 surface water screening level (EPA 1995a) |
| Antimony | 160 | EPA Region 4 surface water screening level (EPA 1995a) |
| Arsenic | 190 | EPA Region 4 surface water screening level (EPA 1995a) |
| Barium | 3.9 | EPA Tier II value (EPA 1996c) |
| Beryllium | 0.53 | EPA Region 4 surface water screening level (EPA 1995a) |
| Cadmium | 0.66 | EPA Region 4 surface water screening level (EPA 1995a) |
| Cobalt | 3 | EPA Tier II value (EPA 1996c) |
| Iron | 1,000 | EPA Region 4 surface water screening level (EPA 1995a) |
| Manganese | 80 | EPA Tier II value (EPA 1996c) |
| Nickel | 87.7 | EPA Region 4 surface water screening level (EPA 1995a) |
| Selenium | 5 | EPA Region 4 surface water screening level (EPA 1995a) |
| Thallium | 4 | EPA Region 4 surface water screening level (EPA 1995a) |
| Zinc | 58.9 | EPA Region 4 surface water screening level (EPA 1995a) |

**Selection of Sediment Screening Levels**

Although the primary focus of the non-radiological assessment is the new surface soils created by receding water levels and potentially affected terrestrial receptors, fluctuating water levels may cause newly created surface soils to be frequently inundated. Thus, potential risks to benthic receptors were also investigated.

Screening levels for sediment-dwelling organisms were obtained from the most widely accepted guidance. EPA Region 4 ecological screening levels were preferentially used, which are primarily Effects Range-Low values from National Oceanic and Atmospheric Administration (Long et al. 1995; Long and Morgan 1991). When values were not available from these sources, screening levels were obtained from most recent EPA guidance (EPA 1996c), which includes EPA sediment quality criteria and EPA sediment quality benchmarks calculated using equilibrium partitioning methods. Ontario Ministry of the Environment sediment screening levels (OME 1992) were also used when values were not available from the sources listed above. Sediment screening levels used in this assessment are presented in Table B-2.

**Selection of Surface Soil Screening Levels**

Surface soil screening levels were obtained from the Oak Ridge National Laboratory On-line Ecological Database (ORNL 1996). These values are based on potential toxicity to earthworms and soil microbes. These receptors could presumably inhabit exposed sediments as water levels recede and exposed sediments become surface soils. EPA Region III ecological soil screening levels were also used (EPA 1995b). Surface soil screening levels used in this assessment are presented in Table B-3.

**Table B-2.** Ecological screening levels for Par Pond and L-Lake sediment.

| Contaminant of Potential Concern | Ecological Screening Level | Source |
|---|---|---|
| Inorganics (mg/kg) | | |
| Aluminum | NA | |
| Antimony | 12 | EPA Region 4 sediment screening level (EPA 1995a) |
| Arsenic | 7.24 | EPA Region 4 sediment screening level (EPA 1995a) |
| Barium | NA | |
| Beryllium | NA | |
| Chromium | 52.3 | EPA Region 4 sediment screening level (EPA 1995a) |
| Cobalt | NA | |
| Copper | 18.7 | EPA Region 4 sediment screening level (EPA 1995a) |
| Lead | 30.2 | EPA Region 4 sediment screening level (EPA 1995a) |
| Manganese | 460 | Ontario Lowest Effects Level (OME 1992) |
| Mercury | 0.13 | EPA Region 4 sediment screening level (EPA 1995a) |
| Nickel | 15.9 | EPA Region 4 sediment screening level (EPA 1995a) |
| Selenium | NA | |
| Thallium | NA | |
| Vanadium | NA | |
| Zinc | 124 | EPA Region 4 sediment screening level (EPA 1995a) |
| Organics (ug/kg) | | |
| Acetone | NA | |
| Xylene | 25 | EPA sediment screening level using Equilibrium Partitioning (EPA 1996c) |

NA = Not available.

### Selection of Terrestrial Plant Screening Levels

Screening levels for assessing risk to terrestrial plants were also gathered from the ORNL database. These screening levels are concentrations of contaminants in soils associated with toxicity to plants. Terrestrial plants would most likely invade newly exposed sediments as water levels recede. Terrestrial plant screening levels used in this ERA are presented in Table B-4.

### Derivation of Toxicity Reference Values

In addition to contaminant concentration screening against ecological screening levels, modeling of potential risks to terrestrial receptors from mercury in Par Pond and L-Lake sediments was also performed. Mercury was chosen for modeling since it has been of concern on Savannah River Site (SRS) waterbodies, at least in part, as a result of mercury inputs from Savannah River water. Unlike most metals, mercury is known to biomagnify in the foodchain, potentially resulting in elevated body burdens for species in higher trophic levels. Other metals were not included in the modeling since they did not generally exceed screening levels used in this ERA (i.e., were not elevated), and are generally not known to biomagnify.

For modeling potential risks of mercury to terrestrial receptors, toxic doses (TRVs) for individual terrestrial receptors were derived for comparison to doses that the receptors may receive in the environment. TRVs were determined for the representative terrestrial receptors ch )sen for this ERA, which are described below. TRVs were identified that

**Table B-3.** Ecological screening levels for Par Pond and L-Lake surface soil.

| Contaminant of Potential Concern | Ecological Screening Level | Source |
|---|---|---|
| Inorganics (mg/kg) | | |
| Aluminum | 600 | ORNL soil screening level for earthworms or soil microbes (ORNL 1996) |
| Antimony | NA[a] | |
| Arsenic | 60 | ORNL soil screening level for earthworms or soil microbes (ORNL 1996) |
| Barium | 3,000 | ORNL soil screening level for earthworms or soil microbes (ORNL 1996) |
| Beryllium | NA | |
| Chromium | 0.4 | ORNL soil screening level for earthworms or soil microbes (ORNL 1996) |
| Cobalt | 1,000 | ORNL soil screening level for earthworms or soil microbes (ORNL 1996) |
| Copper | 50 | ORNL soil screening level for earthworms or soil microbes (ORNL 1996) |
| Lead | 500 | ORNL soil screening level for earthworms or soil microbes (ORNL 1996) |
| Manganese | 100 | ORNL soil screening level for earthworms or soil microbes (ORNL 1996) |
| Mercury | 0.1 | ORNL soil screening level for earthworms or soil microbes (ORNL 1996) |
| Nickel | 200 | ORNL soil screening level for earthworms or soil microbes (ORNL 1996) |
| Selenium | 70 | ORNL soil screening level for earthworms or soil microbes (ORNL 1996) |
| Thallium | NA | |
| Vanadium | 20 | ORNL soil screening level for earthworms or soil microbes (ORNL 1996) |
| Zinc | 200 | ORNL soil screening level for earthworms or soil microbes (ORNL 1996) |
| Organics (μg/kg) | | |
| Acetone | NA | |
| Xylene | 100 | EPA Region III surface soil screening level (EPA 1995b) |

a. NA = Not available.

represent a threshold for sublethal effects. Sublethal effects are defined as those based on the measurement endpoint, impairment of reproduction, growth, or survival. TRVs were derived separately for avian and mammalian species, as discussed below. Since toxicity data for the specific representative receptors chosen were not available, toxicity data from laboratory species were extrapolated to be representative of receptor species. In these instances, a metabolic scaling factor was employed to extrapolate from laboratory species to receptor species, which is also discussed below.

Representative species were chosen to represent the species most likely to be exposed to the highest contaminant concentrations because of its position in the food web, diet (ingestion rate and food type), home range (contained within the area of contamination), and body size. The species selected were assumed to be representative of other species within the same trophic level or guild. Also, the socio-cultural nature of the receptor species (e.g. threatened or endangered species) was also considered. For each of the representative species, information on life history was collected, including diet, average body weight, food ingestion rates, water ingestion rates, home range, and exposure durations (percent of total time that a receptor may reside at the site), when applicable.

For the non-radiological terrestrial modeling in this ERA, the representative species chosen include the bald eagle (*Halieeatus leucocephalus*), eastern cottontail (*Sylvilagus floridanus*), and wood stork (*Mycteria americana*). The bald eagle was chosen primarily since it is a federally threatened species protected by the Endangered Species Act, and is of special concern on SRS. This species is of special social, political, aesthetic, and cultural concern as well, and is widely regarded as a symbol of ecological health. It is

**Table B-4.** Ecological screening levels for Par Pond and L-Lake terrestrial plants.

| Contaminant of Potential Concern | Ecological Screening Level | Source |
|---|---|---|
| Inorganics (mg/kg) | | |
| Aluminum | 50 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Antimony | 5 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Arsenic | 10 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Barium | 500 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Beryllium | 10 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Chromium | 1 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Cobalt | 20 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Copper | 100 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Lead | 50 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Manganese | 500 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Mercury | 0.3 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Nickel | 30 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Selenium | 1 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Thallium | 1 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Vanadium | 2 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Zinc | 50 | ORNL screening level for terrestrial plants (ORNL 1996) |
| Organics (μg/kg) | | |
| Acetone | NA | |
| Xylene | 100,000 | ORNL screening level for terrestrial plants (ORNL 1996) |

NA = Not available.

also representative of other fish-eating raptors found on SRS (e.g., osprey). For conservatism, the bald eagle was assumed to forage on largemouth bass from either Par Pond or L-Lake exclusively. The diet of bald eagles in South Carolina consists almost exclusively of fish, and eagles on SRS have been observed feeding on largemouth bass (Hart et al. 1996). Since they are generally a larger, piscivorous fish, bass contain higher body burdens of mercury than smaller fish, adding additional conservatism to the model. Also, recent studies have detected mercury in Par Pond and L-lake bass, as described below.

Although bald eagles are known to drink water, no mercury was detected in recent surface water samples in L-Lake (Paller 1996) and Par Pond (Paller and Wike 1996a). Hence, exposure to mercury via drinking surface water was not included in the model. Also, most raptors such as eagles generally prey on fish while near aquatic environments and, as a result, would not be expected to come into contact with, and ingest, contaminated sediment. Although an eagle may incidentally ingest sediment while consuming dead fish or carrion on exposed sediments, this exposure route was assumed to be minimal and inconsequential compared to exposure from contaminated fish flesh. Thus, it was not included in the model. The exposure parameters usec' in this ERA for the bald eagle are presented on Table B-5.

**Table B-5.** Summary of receptor parameter information for Par Pond and L-Lake modeling of potential risks from exposure to mercury.

| Receptor | Parameter | Value | Reference |
|---|---|---|---|
| Bald Eagle | Body Weight | 4,500 g | EPA (1993) |
| | Food Ingestion Rate | 0.540 kg/day | Calculated from EPA (1993) |
| | Soil/Sediment Ingestion Rate | NA[a] | NA |
| | Diet Composition | 100% largemouth bass | NA |
| | Home Range (% time on Par Pond or L-Lake) | Assumed to be 100% | NA |
| | Laboratory Toxicity Value | 0.064 mg/kg/day | ORNL (1996) |
| | Body/Metabolic Scaling Factor | 0.61 | NA |
| | Final Toxicity Reference Value | 0.04 mg/kg/day | NA |
| Cottontail Rabbit | Body Weight | 1,134 g | EPA (1993) |
| | Food Ingestion Rate | 0.096 kg/day | Estimated from EPA (1993) |
| | Soil/Sediment Ingestion Rate | 6.3% of diet | Based on jackrabbit, from EPA (1993) |
| | Diet Composition | 93.7% vegetation | NA |
| | Home Range (% time on Par Pond or L-Lake) | Assumed to be 100% | NA |
| | Laboratory Toxicity Value | 0.16 mg/kg/day | ORNL (1996) |
| | Body/Metabolic Scaling Factor | 0.67 | NA |
| | Final Toxicity Reference Value | 0.11 mg/kg/day | NA |
| Wood Stork | Body Weight | 2,268 g | Estimated from EPA (1993) |
| | Food Ingestion Rate | 0.40 kg/day | Estimated from EPA (1993) |
| | Soil/Sediment Ingestion Rate | 7.3% of diet | Based on sandpiper, from EPA (1993) |
| | Diet Composition | 92.7% small fish | NA |
| | Home Range (% time on Par Pond or L-Lake) | Assumed to be 100% | NA |
| | Laboratory Toxicity Value | 0.064 mg/kg/day | ORNL (1996) |
| | Body/Metabolic Scaling Factor | 0.76 | NA |
| | Final Toxicity Reference Value | 0.05 mg/kg/day | NA |

a. NA = Not applicable.

Since no data were available from toxicity studies on the bald eagle, toxicity information was gathered from the Oak Ridge National Laboratory for a study on mercury exposure for the mallard (ORNL 1996). The study investigated reproductive impairment of this avian species from exposure to methyl mercury diacyandiamide in the laboratory. The study calculated a Lowest-Observed-Adverse-Effects-Level (LOAEL) of 0.064 mg/kg/day[2]. The LOAEL was used instead of the No-Observed-Adverse-Effects-Level (NOAEL) since it is based on actual effects. That is, the NOAEL is derived from the lowest concentration at which no effects were observed in the test, whereas the LOAEL is based on the lowest concentration in the laboratory at which adverse effects were

[2] mg/kg/day = milligram of contaminant per kilogram of tissue per day.

observed. To extrapolate between the mallard and the bald eagle, a body size (metabolic) scaling factor was employed. The scaling factor is based on the relative sizes of the laboratory test species and the receptor species; therefore, it adjusts the toxicity data, in this case the LOAEL, based on size-related differences in metabolism. That is, smaller species generally have a higher metabolism and are expected to metabolize and excrete contaminants at a faster rate (ORNL 1996). The metabolic (body size) scaling factor is calculated as follows (derived from ORNL 1996):

$(BM_L/BM_I)^{1/3}$

where: $BM_L$ = body mass of the laboratory test species

$BM_I$ = body mass of the receptor species

This value was multiplied by the test species LOAEL to calculate the bald eagle LOAEL of 0.04 mg/kg/day. The eagle LOAEL for mercury was then used in the model and compared to the modeled mercury dose for Par Pond and L-Lake.

The eastern cottontail was chosen as a representative species because it is a common small, herbivorous mammal found on SRS (Cothran et al. 1991). It would be expected to forage on newly created surface soils (exposed sediments) as the water levels fluctuate in Par Pond and L-Lake and eventually recede in L-Lake over several years. It would be in constant contact with the surface soil, increasing the chances of contaminant exposure. It was also chosen since it is relatively representative of other small mammals found on SRS. The cottontail was conservatively assumed to forage exclusively on exposed Par Pond or L-Lake sediments. Given the size of the rabbit's home range [as small as 0.8 hectare (2 acres); EPA 1993], this may be a realistic (i.e., not overly conservative) assumption. The primary exposure route for this herbivore was assumed to be exposure from consuming contaminated vegetation. Uptake of mercury by plants was modeled using the maximum and average concentrations in soil, which were multiplied by a mercury-specific plant biotransfer factor presented by Baes et al. (1984). Since the cottontail also spends most of its time in contact with the soil, exposure to contaminated surface soils via incidental ingestion was also considered in the model. Again, since no mercury was detected in surface water of either Par Pond or L-Lake, exposure to contaminated drinking water was not considered. The exposure parameters used in this ERA for the cottontail rabbit are presented on Table B-5.

Since no data were available from mercury toxicity studies on the cottontail rabbit, toxicity information was obtained from the Oak Ridge National Laboratory for a study on the rat (ORNL 1996). The rat is known to be especially sensitive to contaminants; therefore, its use as the laboratory species adds conservatism to the assessment. The endpoint for that study was impairment of reproduction from exposure to methyl mercuric chloride. A LOAEL of 0.16 mg/kg/day was calculated for that study. The body scaling factor was also employed to derive the final LOAEL for the rabbit of 0.11 mg/kg/day.

The wood stork was chosen primarily since it is a federally threatened species protected by the Endangered Species Act, and is of special concern on SRS. Like the bald eagle, this species is of special social, political, aesthetic, and cultural concern as well. The wood stork was assumed to forage on small fish from either Par Pond or L-Lake exclusively, since it is known to feed primarily on small fish (Stokes and Stokes 1996). Although wood storks have not been observed foraging on Par Pond or L-Lake in several years (LeMaster 1996), they have been observed on other sites on SRS, and Par Pond and L-Lake may provide foraging areas for this species. Therefore, they were conservatively assumed to forage in these areas. They are also representative of other piscivorous wading birds that occur on Par Pond and L-Lake, such as the great blue heron.

Although wood storks are expected to ingest water, no mercury was detected in recent surface water samples in L-Lake (Paller 1996) and Par Pond (Paller and Wike 1996a). Hence, exposure to mercury via drinking surface water was not included in the model. The wood stork may incidentally ingest sediment while feeding. Thus, incidental ingestion of sediment was included as an exposure parameter. The exposure parameters used in this ERA for the wood stork are presented on Table B-5.

Since no data were available from toxicity studies on the wood stork, toxicity information was gathered from the Oak Ridge National Laboratory for a study of mercury exposure for the mallard, as discussed above for the bald eagle (ORNL 1996). The study calculated an LOAEL of 0.064 mg/kg/day. The body scaling factor was employed to derive the final LOAEL of 0.05 mg/kg/day for the wood stork.

#### B.1.1.2.2. Radiological

Screening values for radiological constituents were established as two times the average concentration in the reference sediment samples (i.e., background). Only radiological constituents that exceeded two times the average background concentration were incorporated into radiological modeling of potential risks to several ecological receptors. A concentration less than two times the background concentration is not indicative of a contaminant release (EPA 1996c) and can be considered statistically insignificant considering the applicable dose limits. It should be noted that, unlike non-radiological contaminants, simple radiological screening levels akin to ambient water quality criteria or Region 4 sediment screening levels do not exist. Hence, only modeling, and not simple screening of concentrations against screening levels, was performed.

The U.S. Department of Energy (DOE) radiation dose limit to aquatic organisms is 1.0 rad per day (DOE Order 5400.5). For terrestrial organisms, this ERA uses a radiation dose limit of 0.1 rad per day. The International Atomic Energy Agency has concluded that "there is no convincing evidence from the scientific literature that chronic radiation dose rates below 1 milligray per day (36.5 rad per year) will harm animal or plant populations" (IAEA 1992).

The radiological portion of this ERA analyzed two of the same receptor species selected for the non-radiological portion of the study (i.e., bald eagle and wood stork) for the reasons described earlier in the non-radiological discussion. Also, potential risks from radiological contaminants were modeled for a generalized minnow-sized fish, largemouth bass, osprey, and the great blue heron. Potential risk to fish from non-radiological contaminants was not modeled since sufficient contaminant data for these receptors were available from several other studies. The conservative dietary assumptions for the species used in the non-radiological portion of this ERA (as described earlier), and the others, were also used in the radiological portion of the analysis.

## B.1.2 Preliminary Exposure Assessment and Risk Characterization

Section B.1.2.1 describes the components of preliminary exposure assessment and Section B.1.2.2 describes the components of risk characterization.

### B.1.2.1 PRELIMINARY EXPOSURE ASSESSMENT

**Non-radiological and Radiological: Exposure Point Concentrations and Contaminant Doses**

Data used to obtain exposure point contaminant concentrations for the waterbodies assessed in this ERA were gathered from several sources. A discussion of the data and studies used to obtain exposure point contaminant concentrations for this ERA is provided below.

*Non-radiological and radiological* sediment contaminant concentration data for Par Pond were obtained from Paller and Wike (1996a). For that study, fifteen surface soil samples spread among each major region of Par Pond (North Arm, Intake Arm, Hot Arm, and Main Body) were collected from exposed sediments during the drawdown in 1995, and each were analyzed for radionuclides and mercury. Also, several sediment samples were collected in each major region of Par Pond and composited for each region, resulting in a total of four samples. Ten samples were also collected from two reference locations, one near Lost Lake and one near Road D. The composite and reference samples were analyzed for radionuclides and mercury, as well as total chlorinated hydrocarbon (TCL) organics, target analyte list (TAL) metals, and polychlorinated biphenyls. The maximum and average concentrations of all non-radiological and radiological contaminants detected in all samples described above were used to represent exposure point contaminant concentrations in sediments/exposed soils. The maximum and average concentrations of mercury from that study were also used to represent the soil concentrations of that constituent in the modeling of exposure for the cottontail rabbit at Par Pond.

For L-Lake, sediment data from recent sampling as part of a Site Evaluation were used to obtain representative exposure point contaminant concentrations (Dunn, Gladden, and Martin. 1996). Selected data from that study germane to this assessment were re-evaluated and analyzed for this ERA (Dunn and Martin 1997). Forty-four surface sediment samples (0 to 6 inches) collected throughout the lake as part of the site evaluation, in both the floodplain and stream channel, were used for this ERA (Appendix F). Samples were also collected from reference areas, including drainages of Steel Creek and Meyers Branch, its main tributary. The L-Lake and reference location samples were analyzed for radionuclides and metals. Organics were not analyzed for and were not evaluated for L-Lake in this ERA since they were not detected in L-Lake sediments in a previous study (Koch et al. 1996). Also, no known major releases or sources of organic contaminants to L-Lake have existed or are known to exist. Maximum and average concentrations of metals and radionuclides in the 44 samples were used to represent exposure point contaminant concentrations in sediments/exposed soils. The maximum and average concentrations of mercury from that study were also used to represent the soil concentrations of that constituent in the modeling of exposure for the cottontail rabbit at L-Lake. Since fluctuating water levels in Par Pond and L-Lake may result in re-inundation of exposed sediments, the sediment contaminant concentrations were considered to be characteristic of both surface soil and sediment. Surface sediment samples were used since they are the horizon of sediments that terrestrial receptors may be exposed to when water levels recede or fluctuate.

Recently collected non-radiological sediment contaminant data for Steel Creek and Lower Three Runs are not abundant. Sufficient data were not available to conduct a thorough sediment contaminant screening for these areas. However, one sediment sample in Steel Creek and Lower Three Runs is collected each year as part of SRS-wide environmental monitoring and analyzed for inorganics, pesticides, and herbicides (WSRC 1996). Data from environmental monitoring of sediments in 1994 and 1995 were used to obtain exposure point contaminant concentrations for each stream.

However, the most recent inorganic data for Lower Three Runs and Steel Creek are from 1994. The samples were collected at a location approximately 4 miles and 1 mile downstream of Par Pond and L-Lake, respectively. Two samples also collected from the same sampling location in each stream, one in 1994 and one in 1995, were used to obtain exposure point contaminant concentrations for pesticides and herbicides. The highest of the two values was used as the exposure point concentration.

Recently collected radiological sediment contaminant data for Steel Creek and Lower Three Runs are not sufficient to conduct a thorough sediment contaminant screening for these areas. Results from seven surface water samples from Steel Creek were reported in the SRS Environmental Data supplement to the 1995 SRS Environmental Report (WSRC 1996). However, only one sample was reported from Lower Three Runs, and this sample was taken at the mouth of the stream.

Due to the nature of the data described above, averages could not be calculated for each class of contaminants at each stream. Organics other than pesticides and herbicides were not analyzed for, presumably since no upstream sources of these contaminants are known to exist or have existed. Also, the absence of extensive sediment data for inorganics, pesticides, and herbicides is somewhat mitigated by several factors. First of all, it is assumed that the contaminated portions of the streams (i.e., the channels) would remain wet or generally inundated under the Proposed Action due to groundwater inputs, flooding, and the maintenance of 10 cubic-foot (0.28-cubic-meter) per second (minimum) stream flow in Lower Three Runs and Steel Creek. This would minimize exposure for many types of terrestrial receptors, such as small mammals, to exposed contaminated sediments, as well as exposure for terrestrial plants that would invade permanently exposed soils. Further, avian predators such as the eagle, and osprey are expected to feed much more often on the open water of the lakes rather than on the smaller streams.

Surface water exposure point contaminant concentrations for Par Pond were obtained from Paller and Wike (1996b). For that study, a surface water sample was collected in each arm of Par Pond (north, middle, west, and near the dam). Samples were collected from near the surface and near the bottom, resulting in a total of eight samples. Each sample was analyzed for TAL metals and radionuclides. Organics were not analyzed for, presumably due to the absence of organic contaminant sources along Par Pond and upstream in Upper Three Runs. No suitable, recently collected background or reference data were available for surface water. Also, since L-Lake water levels are expected to recede to the original stream bed, current surface water data for that waterbody were not assessed since the results would be of limited value.

In addition to the studies listed above, numerous other investigations have been performed on the waterbodies evaluated in this ERA and their ecological receptors. These include, but are not limited to, studies involving surface water chemistry, terrestrial receptors and terrestrial ecology, and aquatic receptors and aquatic ecology. Applicable studies, both non-radiological and radiological, were qualitatively assessed in the ERA and used in the weight of evidence approach to assessing potential ecological risks in the risk characterization step for each site described in Section B.1.2.2.

**Non-radiological: Contaminant Doses for Representative Receptors**

The actual dose of a COPC (in this case, mercury) a receptor species receives as the result of indirect or direct exposure is dependent upon the habits of the species and other factors. As mentioned earlier, a simple model was used to predict dietary exposures for representative receptor species to be compared to TRVs discussed previously. Both the maximum and average detected concentrations of contaminants were used in the model. Model runs were performed for the bald eagle using the maximum and average concentrations of mercury detected in largemouth bass in Par Pond (Paller and Wike 1996b) and L-Lake (Paller 1996). For the cottontail, both the maximum and average detected concentrations in sediments (exposed soils) from the studies discussed above were used to determine contaminant concentrations in terrestrial vegetation and were also used to calculate incidental ingestion of mercury from contaminated soil. For the wood stork, contaminant concentrations in small fish that this receptor was assumed to forage on were obtained from preliminary data generated by the Savannah River Ecology Laboratory as part of on-going wood stork ecology studies (Bryan, Brisbin, and Jagoe 1997). Several species of fish in Par Pond and L-Lake were collected and analyzed for mercury by SREL, including largemouth bass, bluegill, brook silversides, warmouth, sunfish (several types), and lake chubsucker. For each of these species, only fish of a size that the wood stork would be expected to forage on (approximately 120 millimeters or smaller) were collected.

The equations used to calculate the dose of mercury ingested for each exposure route for the bald eagle, wood stork, and cottontail rabbit are presented below.

Incidental Ingestion of Soil/Sediment

Intestinal absorption of mercury in soil/sediment was conservatively assumed to equal 100 percent. Daily intake of mercury as a result of ingestion of soil/sediment was determined using the following equation:

PD ingestion of soil =

$$\frac{(C_{soil} \times FI \times SA \times AF \times F)}{(WR \times CF)}$$

where: PD = predicted dose from ingestion of soil (mg/kg/day)

$C_{soil}$ = concentration in soil (mg/kg)

FI = fractional intake (percent of home range that overlaps impacted area; assumed to be 100%)

SA = percent of diet that equals soil

AF = absorption fraction (unitless; assumed to = 100%)

F = food consumed (mg/day)

WR = body weight (kg)

CF = conversion factor (kg to mg)

Ingestion of Food items

Intestinal absorption of mercury was conservatively assumed to equal 100 percent. The following equation was used to estimate mercury intake from ingestion of contaminated food items:

PD ingestion of food =

$$\frac{(C_{food} \times F \times FA \times FI \times AF)}{(WR \times CF)}$$

where: PD = predicted dose from ingestion of food items (mg/kg/day)

$C_{food}$ = contaminant concentration (vegetation or prey; mg/kg)

F = food consumed (mg/day)

FA = animals/vegetation as a percentage of diet

FI = fractional intake (percent of home range that overlaps affected area; assumed to be 100%)

AF = absorption fraction (unitless; assumed to = 100%)

WR = weight of receptor (kg)

CF = conversion factor (kg to mg)

**Radiological: Contaminant Doses for Representative Receptors**

Radiation dose to receptor species from radiological COCs is dependent on species-specific habits and other species-specific parameters, such as bioaccumulation factors. A simple but conservative model was used to estimate radiation doses to receptor species based on exposure to contaminants in ambient water, uptake of contaminants in water, exposure to contaminants in sediments (for fish), and exposure to contaminants through the ingestion of fish (for avian species).

Radiation dose to fish from exposure to contaminants in ambient water was calculated by multiplying the concentration of each radiological COC in the ambient water by a submersion dose conversion factor. Radiation dose to fish from uptake of contaminants in water was calculated by multiplying the concentration of each radiological COC in the ambient water by a species-specific bioaccumulation factor for the given COC, and by a species-specific internal dose conversion factor. Likewise, the radiation dose to fish from exposure to contaminants in sediments was calculated by multiplying the concentration of each radiological COC in the sediment by an external dose conversion factor. Radiation doses from these three pathways were added together for a total radiation dose. Total radiation dose was calculated for both the maximum and average COC concentrations in applicable media.

Radiation doses to avian species were calculated for the consumption of contaminated food items. It is conservatively assumed that each avian species subsists entirely on a diet of contaminated minnows or largemouth bass, as appropriate for the given avian species. The radiation dose for the avian species was calculated by multiplying the concentration of the COC in the food source by the food consumption rate, and by a species-specific dose conversion factor.

The calculation of dose conversion factors for ingestion for all avian species is similar. For purposes of these calculations, the animals are assumed to possess similar metabolic processes as humans with regard to retention and excretion of radioisotopes; the chemistry of radioisotopes in the animals' bodies is assumed to be the same as that of humans. Equations from the International Commission on Radiological Protection were used to predict the uptake rate and body burden of radioactive material over the lifespan of the animals, which is assumed to be one year. All isotopes were assumed to be uniformly distributed throughout the body of the animal. For purposes of this calculation, the entirety of the alpha and beta particle energies was assumed to be absorbed within the body of the animals. Although only a small fraction of the energy emitted by the isotopes of concern is due to gamma rays, their contribution to the absorbed dose is taken into account by assuming that the animals have the following effective radii: osprey - 1.2 inches (3 centimeters), heron - 2 inches (5 centimeters), bald eagle - 4 inches (10 centimeters), and wood stork - 4 inches (10 centimeters). Tabulated values (Baker and Soldat 1992) of absorbed energy per disintegration were utilized.

Internal dose conversion factors for minnows and largemouth bass were calculated by assuming a steady-state concentration of radioactive material within the tissues of the animal. The absorbed dose due to particulate radiation is calculated as described above for avian species. For photon radiation, the absorbed fractions are assumed to be equal to that for a sphere of water with an effective radius of 0.6 inches (1.4 centimeters) (minnow) and 2.8 inches (7 centimeters) (bass) (Baker and Soldat 1992). The external dose to minnows and largemouth bass in streams is assumed to result from two sources: the water surrounding the fish and the sediment beneath the fish. For purposes of the submersion dose calculation, the minnows and largemouth bass are assumed to be surrounded at all times in their lifespan by an infinite body of water with a uniform distribution of radioactive material. The external dose is assumed to arise entirely from photon radiation. Tabulated values (Baker and Soldat 1992) of immersion dose conversion factors were utilized. External dose conversion factors from exposure of minnows and largemouth bass to sediment on the bottom of the streams were calculated using the MicroShield computer code.

### B.1.2.2 RISK CHARACTERIZATION

#### B.1.2.2.1 Non-Radiological

As identified by EPA (1995a), the preliminary risk characterization step in the ecological risk assessment process compares exposure point contaminant concentrations with screening levels protective of ecological receptors, or contaminant doses to TRVs. Once this step was completed for this study, the results were reviewed to determine whether little or no ecological risk is associated with the Proposed Action at the sites or if additional information must be generated to verify that ecological receptors are at risk. Prior to the comparisons described above, the maximum and average concentrations of inorganic contaminants at each site were compared to two times the average concentrations in background samples. Inorganic COPCs that did not have maximum or average concentrations in excess of two times the background concentration were excluded from further consideration. This step is performed since concentrations of inorganics can be naturally high and not indicative of contaminant releases (EPA 1996c).

The ratio of the exposure point contaminant concentration to the screening level is called the Hazard Quotient (HQ), and is defined as follows:

$$HQ_i = EPC_i/ESL_i$$

where: $HQ_i$ = Hazard Quotient for COPC "i" (unitless)

$EPC_i$ = Exposure Point Concentration for COPC "i" (ug/kg or mg/kg)

$ESL_i$ = Ecological Screening Level for COPC "i" (ug/kg or mg/kg)

When the ratio of the exposure point concentration to its respective screening level exceeded 1.0, adverse impacts were considered possible, and the COPC was retained as COC. The HQ value should not be construed as being probabilistic; rather, it is a numerical indicator of the extent to which an exposure point concentration exceeds or is less than a screening level. When HQ values exceed 1.0, they are an indication that ecological receptors are potentially at risk; additional evaluation or data may be necessary to confirm with greater certainty whether ecological receptors are actually at risk, especially since most screening levels are conservatively derived. Furthermore, other factors, such as low frequency of detection, may mitigate potential risks for a COC with an elevated HQ value. Because of the conservatism inherent in most screening level derivation, EPA Region III (EPA 1994) has suggested that HQs greater than one are indicative of low to moderate potential risk; HQs greater than 10 are indicative of moderate potential risk; and HQs greater than 100 are indicative of high potential risk. However, these classifications were used only as a general guide, and individual exceedances of screening levels and HQ values were each scrutinized.

The use of HQs is probably the most common method used for risk characterization in ERAs. Advantages of this method, according to Barnthouse et al. (1986), include the following:

- The HQ method is relatively easy to use, is generally accepted, and can be applied to any data.

- The method is useful when a large number of contaminants must be screened.

This method of risk characterization has some inherent limitations. One primary limitation is that it is a "no/maybe" method for relating toxicity to exposure. Also, it uses single values for exposure concentrations and screening levels and does not account for the variability in both these parameters nor for incremental or cumulative toxicity. To address cumulative toxicity, HQs were summed for all contaminants with similar modes of action in a given medium to obtain a Hazard Index (HI). Although similar to an HQ in that an HI value of one or greater indicates potential risk, the HI should be interpreted with caution. The HI value may exacerbate the preceding uncertainties in the assessment. For example, most of an HI value may be due to a single contaminant that has a high HQ but a low frequency of detection. Also, ecological toxicity is not necessarily additive even if modes of action are similar. As mentioned above, multiple contaminants may have synergistic, and even ameliorating, effects.

The comparisons described above are presented in site-specific screening tables to select COCs for each individual waterbody assessment section. Screening tables include the frequency of detection for each COPC, as well as the exposure point concentration, and as mentioned earlier, contaminant-specific screening levels. Note that due to the absence of extensive non-radiological data for Lower Three Runs and Steel Creek, the data and results were not tabled. Some contaminants were present in some media for which no suitable screening values were available. In these instances, these contaminants were conservatively retained as COCs and qualitatively assessed. For comparison of doses to TRVs, the HQ method was also used. HQ values for each exposure route were summed to obtain a HI based on all exposure routes.

#### B.1.2.2.2 Radiological

For radiological contaminants, the preliminary risk characterization step in the ecological risk assessment process compares exposure point contaminant concentrations with screening levels (background), and, for the remaining radionuclides, radiation doses to the guideline doses described earlier. For this study, the results of the preliminary risk characterization were reviewed to determine if ecological risk is associated with the Proposed Action at the waterbodies or if additional information must be generated to verify that ecological receptors are at risk.

Again, as a screening value, the maximum and average concentrations of radiological contaminants at each site were compared to two times the average concentrations in background samples. Radiological COPCs that did not have maximum or average concentrations in excess of two times the background concentration were excluded from further consideration. Any inorganic concentration less than two times the background concentration may not be indicative of a contaminant release (EPA 1996c) and can be considered statistically insignificant considering the applicable dose limits. Radiological doses were compared to DOE radiation dose limit for aquatic organisms of 1.0 rad per day (DOE Order 5400.5). For terrestrial organisms, this ERA used a radiation dose limit of 0.1 rad per day. The International Atomic Energy Agency has concluded that there is "no convincing evidence from the scientific literature that chronic radiation dose rates below 1 milligray per day (36.5 rad per year) will harm animal or plant populations" (IAEA 1992).

## B.1.3 Uncertainty Analysis

Uncertainty is associated with all aspects of the ERA process. This section provides a summary of the general uncertainties involved in this ERA, with a discussion of how they may affect the final risk values and conclusions. Some additional discussion of site-specific uncertainties are also contained in site-specific assessment sections below.

Once an ERA is complete, the results must be reviewed and evaluated to identify the types and magnitudes of uncertainties involved. Relying on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. If numerous conservative assumptions are combined in the ERA process, the resulting calculations will propagate the uncertainties associated with each of those assumptions. The resulting bias is toward overpredicting risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered when making risk management decisions.

Generally, risk assessments carry two types of uncertainty: measurement and informational. Measurement uncertainty refers to the variability inherent in measured data. The risk assessment reflects the accumulated variances of the individual values used for several different parameters. Informational uncertainty stems from the limited availability of necessary information. Often the gap between what is needed and what is available is significant; information regarding the effects of some contaminants on wildlife receptors, the biological mechanism of a contaminant, the impact of physiological differences on exposure pathways, or the behavior of a contaminant in various environmental media is often absent.

Uncertainty is associated with each of the steps of the risk assessment process:

- Uncertainty in preliminary problem formulation can result from limited information regarding contaminant sources, release mechanisms, and exposure routes.
- Uncertainty in the ecological effects characterization arises from the quality of the existing screening values and toxicity data to support a determination of potential adverse impacts to ecological receptors.
- Uncertainty associated with the exposure assessment includes the methods used and the assumptions made to determine exposure point concentrations or calculate contaminant doses.
- Uncertainty in risk characterization includes that associated with combining conservative assumptions made in earlier activities.

### B.1.3.1 UNCERTAINTY IN THE PRELIMINARY PROBLEM FORMULATION

For the most part, ecological risk assessments are performed to assess the potential for current or future risks given a constant environmental scenario. Although ERAs are occasionally conducted that are based on modeled data for changing environmental conditions in the future, uncertainties are introduced into the process when assessing potential risks for a future scenario that is not fully understood. In particular, fluctuating water levels in the future under the Proposed Action introduce variables that are difficult to fully account for in the assessment. This includes uncertainty involved in determining contaminant migration and exposure routes. For example, mercury may be resuspended in the water column from fluctuating water levels, but it is difficult to predict the magnitude of such contaminant migration and the extent to which receptors may be adversely affected.

### B.1.3.2 UNCERTAINTY IN THE ECOLOGICAL EFFECTS CHARACTERIZATION

A great deal of uncertainty in this risk assessment arises from the nature and quality of the available toxicity data used to derive screening levels. This uncertainty is reduced when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose related; and when postulated mechanisms of toxicity are similar for laboratory and wildlife species. Most screening levels are based on the most conservative assumptions possible. Although an inherent level of conservatism is needed in a screening-level ecological risk assessment to ensure that the most sensitive receptors are protected, conservative screening levels may heavily overestimate potential risks and the resulting HQ values may be misleading. Both ambient water quality criteria (as used in Region 4 screening levels) and many sediment screening values used in this assessment are based on laboratory studies that do not take into account mitigating or ameliorating physical and chemical conditions in the environment. Therefore, uncertainty is introduced into the assessment, and the results tend to overestimate potential risks.

In addition, ERAs, unlike human health risk assessments, must consider risks to many different species. Calculation of risk values for every potential receptor species is not possible. For this ERA, conservative screening levels *protective of a wide range of ecological* receptors were sought. The underlying assumption associated with the use of these screening levels is that contaminant concentrations in excess of these values are indicative of potential impacts to actual receptors inhabiting the area. However, species-specific physiological differences that may influence an organism's response to a contaminant or subtle behavioral differences that may increase/decrease a receptor's contact with a contaminant are seldom known. Also, some contaminants were present in some media for which no suitable screening levels were available, and as a result, they could not be quantitatively assessed. For these reasons, the use of screening levels, while necessary, will introduce error into the results of an assessment.

Individual receptor species were chosen for modeling of potential risks from exposure to mercury. As discussed earlier, toxicity reference values were obtained for each species. Since no toxicity tests have been conducted for the receptors chosen, laboratory toxicity data from similar species were obtained and extrapolated. Toxicity data for the mallard were used to extrapolate for the bald eagle and wood stork, and rat toxicity data were used for the cottontail rabbit. Both the mallard and rat are generally considered to be sensitive to contaminants. Therefore, the use of data for these organisms may increase the chances that potential risks are being over-predicted. Nonetheless, the use of toxicity data for species other than those investigated in the modeling introduces uncertainty.

### B.1.3.3 UNCERTAINTY IN THE EXPOSURE ASSESSMENT

Uncertainty in the exposure assessment arises mainly in the methods used to obtain exposure point concentrations. The maximum detected contaminant concentrations were generally used to represent the highest contaminant concentrations to which ecological receptors might be exposed. If the samples evaluated in this ERA are representative of contaminant *concentrations associated with the sites, then* this approach is conservative and should overestimate potential risks to ecological receptors. The maximum concentration of a contaminant in a given medium may have been collected in a "hot spot" of contamination, and may be much higher than the remaining values in the data set. Again, although use of maximum values is appropriate for screening in an ERA, they may grossly overpredict potential risks. To somewhat mitigate these uncertainties, average concentrations were also used, but they do not fully account for the uncertainties involved in selecting exposure point contaminant concentrations.

Also, several input parameters were used in the modeling calculations for each receptor. To maintain a relatively high level of conservatism in this screening-level assessment, worst-case values were used to calculate risk values for each receptor (e.g., exposure to maximum concentration of mercury in fish for the wood stork and eagle). However, it is highly unlikely that the very conservative values used for each exposure parameter will hold true in the environment. The use of several of these assumptions in the calculations increases the chances that the risks are over-predicted, introducing uncertainty into the results.

Furthermore, data used to obtain exposure point contaminant concentrations and contaminant concentrations in fish for the mercury modeling were obtained from several different sources. Although each of these studies was scrutinized to determine if it was adequate for its use in this assessment, the use of data from different sources contributes to uncertainties. For example, laboratory analyses were performed by different laboratories which may have different detection limits in their methods, slightly different analytical protocols, and so forth.

#### B.1.3.4 UNCERTAINTY IN THE RISK CHARACTERIZATION

Uncertainty in the risk characterization is affected by all aspects of the ERA process described in the above sections. Uncertainty in risk characterization also stems, in part, from the fact that different components of the ERA are combined and compared in this step. Each of those components already contains different types of uncertainty, as discussed above. Thus, uncertainties may be propagated when these components are combined. To try to reduce the overall uncertainty in the risk assessment, the weight of evidence approach is used to make risk decisions. This approach takes the results of all aspects of the assessment into account, including the uncertainties, to make determinations of potential risk/no risk.

## B.2 PAR POND

The major elements of preliminary problem formulation, ecological effects assessment, and exposure assessment for the Par Pond ERA are discussed in Section B.1. Hence, only the risk characterization results and discussion are presented in this section.

### B.2.1 NON-RADIOLOGICAL CONTAMINANTS

**Risk Characterization - Results**

The results of the risk characterization step for each aspect of the Par Pond assessment are presented below.

**Surface Water**

In Par Pond surface water, barium (HQ = 4.62), beryllium (HQ = 2.83), and cadmium (HQ = 1.52) had HQ values in excess of one (Table B-6). These three metals also had average concentrations with HQs greater than 1 (Table B-7). Since no suitable site-specific background data were available, concentrations were not compared to two times the average background concentration.

**Sediments**

Only the maximum concentration of mercury exceeded its sediment screening level, with a HQ value of 3.72 (Table B-8). Most contaminants' maximum concentrations did not exceed two times the average background concentration. Thallium was conservatively retained as a sediment COC since the maximum detected concentration exceeded two times the average background concentration and no suitable sediment screening level was available. Acetone was conservatively retained as a sediment COC since no suitable screening level was available. No inorganic contaminants had average concentrations in excess of two times their background concentrations (Table B-9). Acetone was also conservatively retained as a COC under the average scenario since no suitable screening level was available.

**Surface Soil**

Manganese (HQ = 3.96) and mercury (HQ = 4.8) were present in maximum concentrations in excess of screening levels (Table B-10). Thallium was conservatively retained as a COC

**Table B-6.** Selection of surface water contaminants of concern for Par Pond maximum contaminant concentrations.

| Contaminant of Potential Concern | Frequency of Detection | Average Background (Reference) Concentration[a] | Maximum Detected Concentration[b] | Surface Water Screening Level[c] | Hazard Quotient[d] | Retained as a COC? |
|---|---|---|---|---|---|---|
| Inorganics (μg/L) | | | | | | |
| Aluminum | 8/8 | NA[e] | 79 | 87 | 0.91 | No - does not exceed screening level |
| Antimony | 3/8 | NA | 3 | 160 | 0.02 | No - does not exceed screening level |
| Arsenic | 5/8 | NA | 4 | 190 | 0.02 | No - does not exceed screening level |
| Barium | 8/8 | NA | 18 | 3.9 | 4.62 | Yes - exceeds screening level |
| Beryllium | 1/8 | NA | 1.5 | 0.53 | 2.83 | Yes - exceeds screening level |
| Cadmium | 1/8 | NA | 1.0 | 0.66 | 1.52 | Yes - exceeds screening level |
| Cobalt | 2/8 | NA | 2 | 3 | 0.67 | No - does not exceed screening level |
| Iron | 8/8 | NA | 318 | 1,000 | 0.32 | No - does not exceed screening level |
| Manganese | 8/8 | NA | 73 | 80 | 0.91 | No - does not exceed screening level |
| Nickel | 2/8 | NA | 5 | 87.7 | 0.06 | No - does not exceed screening level |
| Selenium | 3/8 | NA | 3 | 5 | 0.6 | No - does not exceed screening level |
| Thallium | 2/8 | NA | 2.7 | 4 | 0.68 | No - does not exceed screening level |
| Zinc | 3/8 | NA | 4 | 58.9 | 0.07 | No - does not exceed screening level |

a. No suitable data was available.
b. Source: Paller and Wike (1996b).
c. See Table B-1.
d. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
e. NA = Not available.

**Table B-7.** Selection of surface water contaminants of concern for Par Pond average contaminant concentrations.

| Contaminant of Potential Concern | Frequency of Detection | Average Background (Reference) Concentration[a] | Average Concentration[b] | Surface Water Screening Level[c] | Hazard Quotient[d] | Retained as a COC? |
|---|---|---|---|---|---|---|
| Inorganics (µg/L) | | | | | | |
| Aluminum | 8/8 | NA[e] | 47 | 87 | 0.54 | No - does not exceed screening level |
| Antimony | 3/8 | NA | 2 | 160 | 0.01 | No - does not exceed screening level |
| Arsenic | 5/8 | NA | 2.5 | 190 | 0.01 | No - does not exceed screening level |
| Barium | 8/8 | NA | 10.5 | 3.9 | 2.69 | Yes - exceeds screening level |
| Beryllium | 1/8 | NA | 1.4 | 0.53 | 2.64 | Yes - exceeds screening level |
| Cadmium | 1/8 | NA | 1 | 0.66 | 1.52 | Yes - exceeds screening level |
| Cobalt | 2/8 | NA | 2 | 3 | 0.67 | No - does not exceed screening level |
| Iron | 8/8 | NA | 272.5 | 1,000 | 0.27 | No - does not exceed screening level |
| Manganese | 8/8 | NA | 40 | 80 | 0.5 | No - does not exceed screening level |
| Nickel | 2/8 | NA | 3.5 | 87.7 | 0.04 | No - does not exceed screening level |
| Selenium | 3/8 | NA | 2.5 | 5 | 0.5 | No - does not exceed screening level |
| Thallium | 2/8 | NA | 2.5 | 4 | 0.63 | No - does not exceed screening level |
| Zinc | 3/8 | NA | 3 | 58.9 | 0.05 | No - does not exceed screening level |

a. No suitable data was available.
b. Source: Paller and Wike (1996b).
c. See Table B-1.
d. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
e. NA = Not available.

**Table B-8.** Selection of sediment contaminants of concern for Par Pond maximum contaminant concentrations.

| Contaminant of Potential Concern | Frequency of Detection | Average Background (Reference) Concentration[a] | Maximum Detected Concentration[a] | Sediment Screening Level[b] | Hazard Quotient[c] | Retained as a COC? |
|---|---|---|---|---|---|---|
| Inorganics (mg/kg) | | | | | | |
| Aluminum | 4/4 | 6,456 | 2,100 | NA[d] | --- | No - does not exceed two times the average background |
| Antimony | 1/4 | 2.7 | 4 | 12 | --- | No - does not exceed two times the average background |
| Arsenic | 1/4 | 2.5 | 4 | 7.24 | --- | No - does not exceed two times the average background |
| Barium | 4/4 | 43.4 | 24.7 | NA | --- | No - does not exceed two times the average background |
| Beryllium | 4/4 | 0.2 | 0.1 | NA | --- | No - does not exceed two times the average background |
| Chromium | 4/4 | 6.6 | 3.2 | 52.3 | --- | No - does not exceed two times the average background |
| Cobalt | 4/4 | 0.6 | 0.7 | NA | --- | No - does not exceed two times the average background |
| Copper | 4/4 | 3.3 | 2.4 | 18.7 | --- | No - does not exceed two times the average background |
| Lead | 4/4 | 5.7 | 6.1 | 30.2 | --- | No - does not exceed two times the average background |
| Manganese | 4/4 | 137.4 | 396.2 | 460 | 0.86 | No - does not exceed screening level |
| Mercury | 127/149 | 0.067 | 0.484 | 0.13 | 3.72 | Yes - exceeds two times the background and screening level |
| Nickel | 4/4 | 2.5 | 1.3 | 15.9 | --- | No - does not exceed two times the average background |
| Selenium | 1/4 | 2.8 | 4 | NA | --- | No - does not exceed two times the average background |
| Thallium | 2/4 | 3.0 | 6.4 | NA | --- | Yes - exceeds two times the average background and no suitable screening level available |
| Vanadium | 4/4 | 9.9 | 5.5 | NA | --- | No - does not exceed two times the average background |
| Zinc | 4/4 | 6.6 | 5.2 | 124 | --- | No - does not exceed two times the average background |
| Organics (ug/kg) | | | | | | |
| Acetone | 4/4 | 18.7 | 20.6 | NA | --- | Yes - no suitable screening level available |
| Xylene | 2/4 | 0.18 | 0.46 | 25 | 0.02 | No - does not exceed screening level |

a. Source: Paller and Wike (1996a).
b. See Table B-2.
c. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
d. NA = Not available.

**Table B-9.** Selection of sediment contaminants of concern for Par Pond average contaminant concentrations.

| Contaminant of Potential Concern | Frequency of Detection | Average Background (Reference) Concentration[a] | Average Concentration[a] | Sediment Screening Level[b] | Hazard Quotient[c] | Retained as a COC? |
|---|---|---|---|---|---|---|
| Inorganics (mg/kg) | | | | | | |
| Aluminum | 4/4 | 6,456 | 1,619 | NA[d] | --- | No - does not exceed two times the average background |
| Antimony | 1/4 | 2.7 | 3.4 | 12 | --- | No - does not exceed two times the average background |
| Arsenic | 1/4 | 2.5 | 3.4 | 7.24 | --- | No - does not exceed two times the average background |
| Barium | 4/4 | 43.4 | 17.2 | NA | --- | No - does not exceed two times the average background |
| Beryllium | 4/4 | 0.2 | 0.1 | NA | --- | No - does not exceed two times the average background |
| Chromium | 4/4 | 6.6 | 2.4 | 52.3 | --- | No - does not exceed two times the average background |
| Cobalt | 4/4 | 0.6 | 0.5 | NA | --- | No - does not exceed two times the average background |
| Copper | 4/4 | 3.3 | 1.8 | 18.7 | --- | No - does not exceed two times the average background |
| Lead | 4/4 | 5.7 | 4.1 | 30.2 | --- | No - does not exceed two times the average background |
| Manganese | 4/4 | 137.4 | 169.1 | 460 | --- | No - does not exceed two times the average background |
| Mercury | 127/149 | 0.067 | 0.077 | 0.13 | --- | No - does not exceed two times the average background |
| Nickel | 4/4 | 2.5 | 1 | 15.9 | --- | No - does not exceed two times the average background |
| Selenium | 1/4 | 2.8 | 3.1 | NA | --- | No - does not exceed two times the average background |
| Thallium | 2/4 | 3.0 | 4.1 | NA | --- | No - does not exceed two times the average background |
| Vanadium | 4/4 | 9.9 | 3.6 | NA | --- | No - does not exceed two times the average background |
| Zinc | 4/4 | 6.6 | 3.3 | 124 | --- | No - does not exceed two times the average background |
| Organics (ug/kg) | | | | | | |
| Acetone | 4/4 | 18.7 | 16.2 | NA | --- | Yes - no suitable screening level available |
| Xylene | 2/4 | 0.18 | 0.28 | 25 | 0.01 | No - does not exceed screening level |

a. Source: Paller and Wike (1996a).
b. See Table B-2.
c. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
d. NA = Not available.